Development and Characterization of an aqueous dispersion based nano zinc oxide for cosmetic application in sunscreens

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ABSTRACT

Development of an additive based nanostructured zinc oxide nano through a grinding process and physicochemical surface functionalization allows the formation of a stable aqueous dispersion having high solids and thus, high capacity for absorption of ultraviolet radiation. Due this reason, it is an ideal product for using as a physical screen in cosmetic applications, providing the following benefits: Sun protection in the UVA region, the nano-ZnO is an excellent physical filter which has a solar radiation absorption throughout the UVA region and extends even UVB region, becoming in a complement for the physical filter based nano-TiO2. The solids content of the aqueous dispersion of nano ZnO was optimized up to 60% and through this concentration is possible to regulate the material incorporation in the formulation of cosmetic creams.

Keywords: Nanoparticles, ZnO, physical filter, UV-protection.

1 INTRODUCTION

Nanotechnology is the term given to the areas of science and engineering where phenomenas occur at the nanoscale, which are used in the design, characterization, production and application of materials, structures, devices and systems.[1] The recommendation issued in 2011, the European Commission defines "nano materials" to this natural material, incidental or manufactured containing particles in an unbound state or as an aggregate or agglomerate, wherein at least 50% of said particles have a size distribution within the range of 1-100 nanometers (nm) and has a specific surface area above 60 m2 / cm3 volume [2]. However, in specific cases related to environment, health, safety or competitiveness, the threshold distribution of nanoparticle size of 50% may be replaced by a threshold between 1-50% and / or its specific surface must be at least less than 60 m2 / cm3. In the case of fullerenes, graphene flakes and carbon nanotubes single wall, shall be considered as nanomaterials as long as one or more external dimensions are below 1 nm[3].

It is no news that cosmetic companies know that nanotechnology is the way of the future and is considered as one of the most promising emerging technologies [4]. Cosmetic manufacturers use versions of nanoscale ingredients to provide better UV protection, penetrating the skin deeper, longer lasting effects of the active ingredients, enhance the color and improve the quality of finish [5]. The rise of nanoscale materials in the cosmetics industry is due to the fact that the nanoparticles acquire new properties that differ from the particulates. These properties include color, transparency, solubility and chemical reactivity, making nanomaterials attractive for cosmetics and personal care[6].

The nano-ZnO is an excellent physical filter which has a solar radiation absorption throughout the UVA region and extends even UVB region, becoming in a complement for the physical filter based nano-TiO2 [7]. The complete or partial replacement of chemical filters by physical filters is the solution for our babies, children and people with sensitive skin [8]. Avoids "ghosting”, this effect is caused by the particle size applied in creams (microns), which causes a direct interference with solar radiation leaving as a result a white color on the surface of the skin, which can last for a long time due it is not absorbed. In this work the morphological and structural characterization of nanocomposite and spectrophotometric characterization is presented in order to determine the absorption capacity of UV-A and UV-B radiation as a function of particle size, as the particle size becomes smaller, absorbance in the ultraviolet region increases. According to the dynamic light diffraction characterization and transmission electron microscopy we are able to identify the particle size of the aggregates, which have a volume average of 180 nm, these aggregates in turn are composed of nanoparticles of size 5 to 20 nm, these particles are the responsable of improvement the capability of UV absorption. The characterization by X-ray diffraction evidence nanoparticle formation by increasing the width of the signals. This effect is caused by diffraction signals contribution between grain boundaries.The nano-ZnO offers the advantage of having a minimum particle size (approx. 150 nm) with no interference in the visible solar radiation, making it totally transparent in the visible, so the white layer does not leave any residue when sunscreen is applied.

2 EXPERIMENTAL

All chemicals were purchased as standard grade without purification.

Micronized zinc oxide (golden seal), chemical dispersant. Deionized water was provided by a water purification plant and used without purification.

The preparation of nanoparticles was performed by means of a physico-chemical process of grinding by top-down method using a blasting material to reduce the particle size. The developed product was optimized to a solids content of 60% in aqueous dispersion, the results are presented below.

3 CHARACTERIZATION

3.1 Particle size-DDL

The particle size analysis is performed in a dynamic light scattering ZETATRAC mark. Where the following particle size distribution is presented in Figure 1. Table 1 contains a summary of the parameters calculated by DDL equipment.

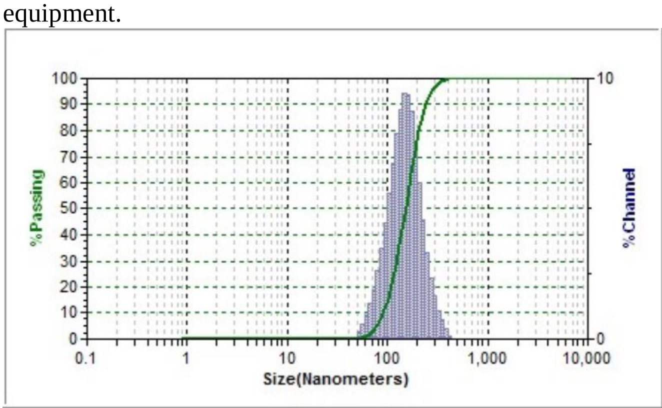

Figure 1. Particle Size Distribution.

MV	160 nm
MN	105 nm
CS	38 m^2/cm^3
Z	-59.27 mV
% Solid	60

Table 1. Average Volume (MV) Average Number (MN), surface area (CS) Zeta potential (Z), an aqueous dispersion of nano ZnO obtained by DDL.

3.2 X-Ray Difraction

The crystal structure of the raw material is maintained during processing. The diffraction peak broadening which occurs once the product is processed is caused by the decrease in particle size (crystallites), since the boundaries or grain boundaries are increased, which contribute to the measurement. The crystal structure of the sample in both crystallographic phase is consistent with the Zincite, this material has a hexagonal crystal structure. (Figure 2).

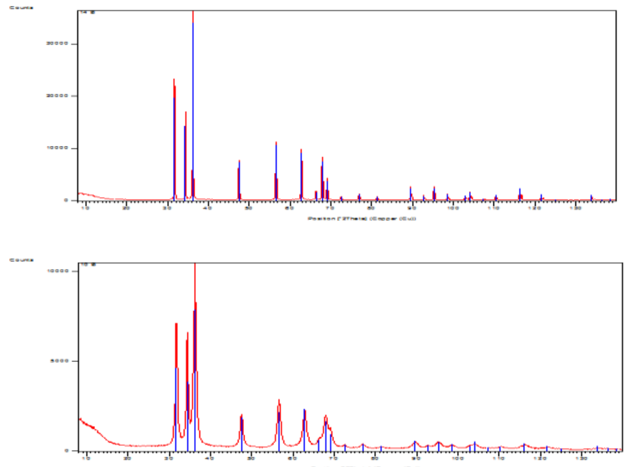

Figure 2. Spectra XRD, Raw material (upper) finished product (bottom).

3.3 Transmission Electron Microscopy

TEM images show an irregular morphology of the raw material with approximately 600 nm. Once the product morphology processing remains irregular particles but with a size of crstal 5 to 20 nm dispersed in water to form agglomerates as DDL 160 to 200 nm was observed. (Figure 3)

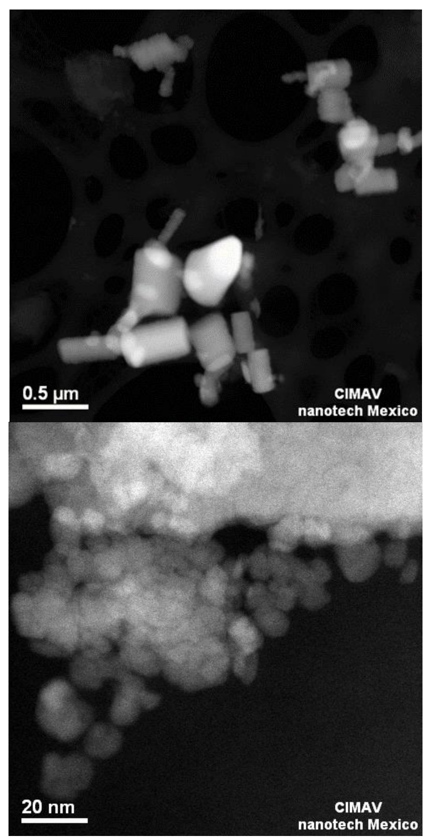

Figure 3. TEM image of raw material (upper) and finished product (bottom).

3.4 UV-Vis

The following spectrum of UV-Vis difference is seen in the UV absorption as a function of particle size obtained at various grinding times. Where the product with an average size by volume of 180 nm has increased absorption of UV-A and UV-B radiation, making it suitable for incorporation into cosmetic emulsions. (Figure 4).

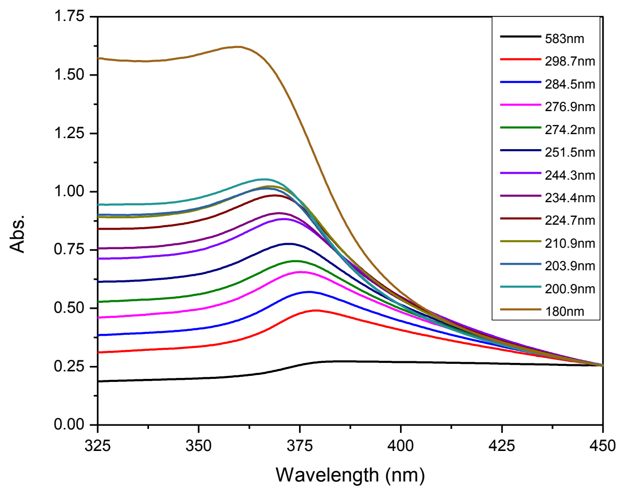

Figure 4. UV-Vis spectra of aqueous dispersions of nano ZnO with different average particle size analyzed by DDL.

In Figure 5 a comparative absorption spectrum of radiation nanoparticles zinc oxide and titanium dioxide are shown, as seen both products complement the absorption region preventing the passage of harmful radiation to the skin.

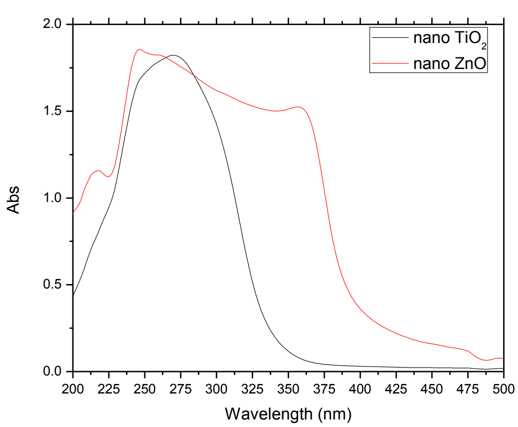

Figure 5. Comparative absorption spectrum of UV radiation and nano ZnO nano TiO_2.

4 APPLICATION DEVELOPMENT

Zinc oxide has been tested in emulsions for cosmetic usage.

It is posible to get a good incorporation of zinc oxide either aqueous phase or the mixture of oil and water phases at 75°C. In the aqueous phase, once all of the ingredients (deionized water, emollients, stabilizers,...) have been added, mixed and heated at 75°C then it is possible the addition of zinc oxide (which is at room temperature). Same case when zinc oxide is added in the mixture of both phases. The concentrations vary between 5-15%.

Finally, cool down until the emulsion will become creamy at 30-40°C. (Figure 6)

The contribution of zinc oxide has been the key to get the critical wavelength of 370nm required by NOM-141-SSA1/SCFI-2012.

Figure 6. Incorporating aqueous dispersion of ZnO in cosmetic emulsions.

5 CONCLUSIONS

Nanotechnology is an innovative science that has been implemented by various industries such as electronics, aerospace, automotive, energy, pharmaceutical, food, cosmetics, among others. This because through manipulation of particle size can be increased or provide new properties to conventional materials. In the cosmetic industry has been used to improve product quality and differentiating factors and provide additional competitive advantages, resulting in increased sales in cosmetic signatures.

The main features provided by the nano-ZnO are:

- No allergic reactions;
- ghosting disappears;
- It is transparent;
- not provide greasy appearance.

In addition to the recent concern of the negative effects of solar radiation can cause, today various kinds of cosmetics, different creams blockers such as lotions, up remover bases, shadows, make-up, among others, are implementing the usage of various sunscreens with zinc oxide nanoparticles as an ideal candidate because of its effectiveness against ultraviolet radiation.

ZnO nano is now in an alternative physical filter as in cosmetic applications, completing the spectrum of protection in the UV-A range.

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